15 January 1972

Materiel Test Procedure 7-2-009*
Aberdeen Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

AIRCRAFT ROCKET SUBSYSTEMS

1. OBJECTIVE

This procedure is designed for guidance in the testing (particularly engineering testing) of air-to-ground rocket subsystems to determine safety, performance, reliability, and durability; to obtain ballistic data for rockets fired from the launchers; and to assure that the rocket subsystem meets the requirements of the MN. Also included is a safety evaluation leading to a Safety Release for service testing.

2. BACKGROUND

Air-to-ground rocket subsystems for the 2.75-inch FFAR rocket are currently being utilized by the U. S. Army on the UH-1 Iroquois and AH-1G (HUEYCOBRA) helicopters as area weapons and in aerial artillery roles. Improved rocket subsystems will arm forthcoming high-speed-attack helicopters. Each helicopter armament system requires testing and evaluation with regard to the features stated in the objective above.

The typical air-to-ground rocket subsystem utilizes an electrically fired, open-breech, multiple-tube launcher (7-tube and 19-tube launchers are most common). Paired (or multiple paired) launchers are mounted on each side of the aircraft (Fig. 1). The launcher may mount directly to mechanical and electrical attachment points provided on the aircraft or may be installed to an armament subsystem, capable of mounting different types of weapons to suit mission requirements, which has been mounted to the aircraft frame hard points. The launchers are not usually adjustable in elevation when airborne, but may be preset within limits of elevation relative to the airframe when installed.

Typically, rockets are fired in pairs or multiple pairs, as preselected by the pilot by setting a selector switch on the rocket intervalometer control located in the aircraft cockpit. Other controls provided for the pilot are the safe-arm switch, a "rounds remaining" counter, a launcher jettison switch, and the rocket firing button. Aiming and firing functions are performed by the pilot. A pilot's sight, frequently of the infinity-reflex type, is provided. The pilot sets the sight at the proper elevation (line of sight relative to the aircraft waterline) for the required range, airspeed, and aircraft firing or launching altitude according to the range firing table provided, and flies the aircraft toward the target, firing the rockets when the target is centered on the sight pattern.

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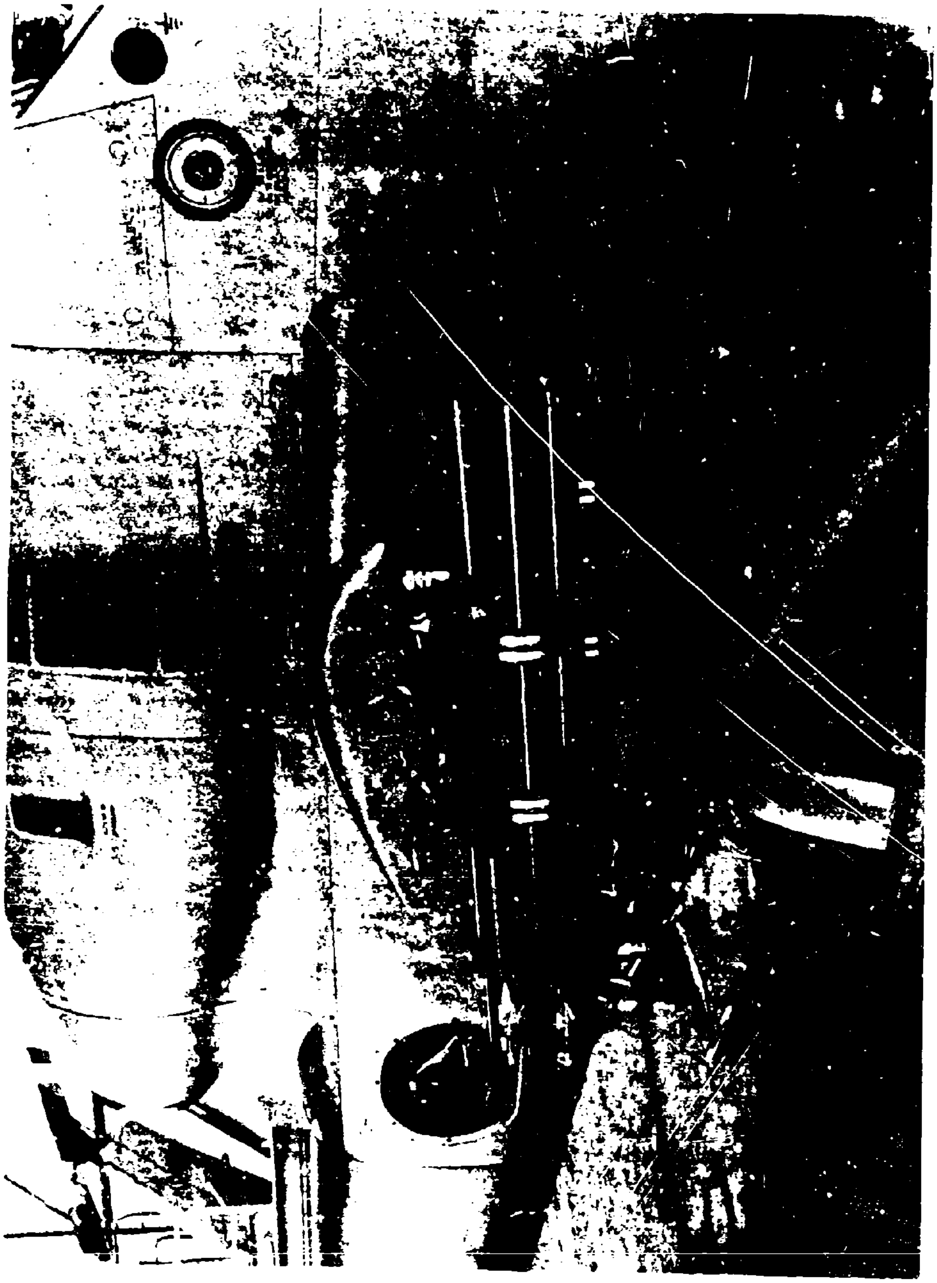

Figure 1. Two 7-Tube Aircraft Rocket Launchers (M158A1) Mounted to Right Side, External Stores Pylon of HUEYCOBRA Rotary-Wing Aircraft Before Loading and Firing.

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13. ABSTRACT

Describes a method for evaluation of air to ground rocket subsystem performance characteristics. Provides procedures for test preparation, physical characteristics, safety evaluation, high temperature (+145°F), low temperature (-50°F), sand, dust, humidity, salt spray, fungus, rain, freezing rain, vibration, static loading, firing tests, durability, accuracy, and dispersion.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aircraft Armament						
Aircraft Subsystem						
Rocket						

3. REQUIRED EQUIPMENT

a. An aircraft of the type that will be used with the rocket subsystem being tested; accessories for mounting and firing the subsystem, including a pilot's (rocket firing) sight; and, if required, other armament subsystem(s) intended for use on the aircraft concurrently with the rocket firing subsystem.

b. Environmental test chambers, gages, photographic equipment, etc., as required for physical measurements and environmental tests as specified in paragraph 6.2.

c. Instrumented test range, large enough to permit the firing of rockets under all required conditions of employment, set up as illustrated in Figure 3 (para. 6.2.4.4).

d. Test stand for ground-to-ground firings of the rocket launcher (detached from helicopter), with attachments for simulating launcher attachment to the aircraft and firing controls as found in the aircraft, and of sufficient strength and mass to maintain the required launcher elevation and azimth during ripple firing.

4. REFERENCES

A. AR 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions.
B. MIL-STD-810B, Environmental Test Methods.
C. AMCR 700-34, Release of End Items for Issue.
D. TECR 385-6, Verification of Safety of Materiel During Testing
E. TOP 1-2-602, Electrical Power Measurements for Vehicle Subsystems.
F. MTP 2-2-614, Toxic Hazards Test for Vehicles.
G. MTP 2-2-815, Rain and Freezing Rain.
H. MTP 3-2-500, Weapon Characteristics.
I. MTP 3-2-615, Radio Frequency Radiation Hazards to Electro-explosive Devices.
J. MTP 3-2-811, Noise and Blast Measurements.
K. MTP 4-2-015, Close Support Rockets and Missiles.
L. MTP 4-2-503, Safety Evaluation - Close Support Rockets and Missiles.
M. MTP 4-2-818, Testing for Fungus Resistance.
N. MTP 4-2-819, Sand and Dust Testing of Ammunition.
O. MTP 4-2-820, Humidity Tests.
P. MTP 5-1-031, Cinetheodolites.

5. SCOPE

5.1 SUMMARY

This MTP describes the following tests for evaluating air-to-ground rocket subsystems:

a. Measurement of physical, electrical, and operating characteristics.

b. Environmental tests for determining whether safety hazards or other test item failures result from extreme climatic exposure, laboratory vibration, or effects of sustained linear acceleration as simulated by static loading.

c. Ground-to-ground rocket firing tests from test stands or from grounded aircraft to determine safety, performance, durability, and reliability of the launcher; compatibility of launcher and aircraft; and ballistic characteristics of rockets fired from the launcher.

d. Airborne rocket firing tests to determine operability of the test launcher under all required aircraft loading and operating conditions, and to determine range probable errors and deflection probable errors of rockets fired from various aircraft altitudes, rocket launcher elevations (overall, in degrees or mils), and air speeds.

The procedures outlined herein were prepared primarily for use in the testing of rocket launchers and associated ammunition and equipment developed for rotary wing aircraft. They are generalized to a degree, however, and therefore are partially applicable also to tests involving fixed wing aircraft.

5.2 LIMITATIONS

The following procedures are not included:

a. Procedures for determining noise levels (covered by MTP 3-2-811), presence of toxic gases from rocket exhaust within the aircraft cockpit (MTP 2-2-614), and similar human factors safety considerations.

b. Procedures for conducting an electromagnetic hazards test on rocket launchers (MTP 3-2-615).

c. Rocket ammunition tests, which are specified in MTP 4-2-503 (safety) and MTP 4-2-015 (performance).

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 General

The launcher to be tested is compared with applicable drawings and with similar launchers. The construction and the methods and principles of operation are studied.

Preparations for individual subtests are described under paragraph 6.2.

6.1.2 Safety Statement and Safety-of-Flight Release

Before conducting engineer design or engineering tests, the test agency should receive from the developer a Safety Statement or an interim Safety Statement that will be used to develop safe operating procedures as prescribed in TECR 385-6. In addition, before any aerial activity is performed by a test agency, the agency must receive a safety-of-flight release from the U. S. Army Aviation Systems Command (AVSCOM)

Safety restrictions contained in the Safety Statement should be reviewed and discussed with test personnel. The test director is responsible for assuring that all test personnel are thoroughly briefed on all safety procedures and limitations connected with the test item prior to conducting the test.

6.1.3 Characteristics Data Sheet

A characteristics data sheet, suitable for the formal report and other uses, is assembled and printed. It consists of a photograph of the test item (exploded or cross-sectional view preferred) reduced in size and combined, on a glossy 8- by 10-inch print, with a listing of all principal physical and performance characteristics. Guidance is provided in MTP 3-2-500.

6.2 TEST CONDUCT

The subtests described below are conducted as applicable. Subtests are frequently conducted sequentially to minimize requirements for large test samples (launchers), ammunition, and costs. Table I shows typical test sequences.

Table I - Typical Test Sequences

Test Group A (One Launcher)	Test Group B (One Launcher)	Test Group C (Two Launchers)
Physical measurements (par. 6.2.1) High temperature operation (par. 6.2.3.1) Low temperature operation (par. 6.2.3.1) Operational vibration (par. 6.2.3.4) Fungus (par. 6.2.3.2)	Physical measurements (par. 6.2.1) Static loading (par. 6.2.3.5) Sand and dust (par. 6.2.3.2) Salt Spray (par. 6.2.3.2) Durability firing (par. 6.2.4.1)	Physical measurements (par. 6.2.1) Ground firing (pars. 6.2.4.2 and 6.2.4.3) Humidity testing (one launcher) (par. 6.2.3.2) Rain and freezing rain (one launcher) (par. 6.2.3.3) Aerial firing (par. 6.2.4.4)

6.2.1 Physical Characteristics

Upon receipt of the test item the following measurements and inspections are made:

a. Stargage measurements (internal diameters) are made of each of the launcher tubes, at several points along the tubes (including bulkhead locations).

b. Trammel points are scribed on the launcher for later use in determining whether deformation of the launcher structure occurred during the test.

c. The following critical dimensions on the launcher are identified and measured for conformance with drawings: the distance between mounting lugs, distance from electrical contact to rocket detent, distances between tubes and alignment of tubes (multiple launchers) within the launcher structure.

d. The weight and center of gravity of the launcher (loaded and empty) are determined and compared with applicable requirements (MN, TC, etc.).

e. The loading and unloading characteristics and the type of electrical contact and rocket detent (muzzle or breech loading, spring-loaded electrical contact, etc.) are noted and recorded and, for multiple launchers, the firing order.

f. The force required to release the rocket from the launcher detent (detent force) is measured. The measurement is made by applying axial force through a measuring device, such as a spring scale, with a hand winch and cable attached to an inert rocket installed in a launcher tube. The actual forces applied are noted on the measuring device. Five readings are taken for each launcher tube and averaged.

NOTE: If the launcher detent is of a type that is actuated by impingement of rocket motor exhaust gases from firing, the above procedure must be modified. Measurement of detent characteristics on this type of launcher detent may be made by applying a specified minimum value of axial force and observing rocket restraint in the tube. If rocket release characteristics are required, a force that simulates the effect of rocket exhaust gases is applied to the impingement area of the detent. Axial force then may be applied to the rocket motor, as noted above. The need for performing this latter type of test may be determined by prior checks to ascertain the force required to deflect the detent and the dimensional clearance between the rocket motor and the fully deflected detent.

g. The electrical wiring characteristics of the launcher are noted and recorded. Inspection is made for proper shielding and grounding of the firing circuits and for protection of the electrical wiring from damage due to handling or firing. Continuity, resistance, and insulation checks are performed in accordance with the applicable drawings and specifications.

h. Launchers are installed to the applicable aircraft, and an appropriate armament subsystem is used as indicated in paragraph 2, if required. Ease of installation is checked as well as proper fit and engagement of the launcher with the armament subsystem and components. The launcher electrical circuit connector must be easily engaged, and the launcher must be readily installed to a standard bomb shackle if this type of mounting is used.

i. The jettison features (mechanical, electrical, or electro-explosive) are identified and given an operational check. Circuit continuity checks are performed on electroexplosive jettison devices.

j. The aircraft weight-balance characteristics are obtained as follows: The center of gravity (CG) of the aircraft, with fully loaded armament subsystem(s) installed and full crew and fuel, is determined at maximum gross weight and at 20 minutes fuel supply, and any critical conditions that adversely affect the CG location are noted.

6.2.2 Safety Evaluation

The safety evaluation is a portion of the engineering test that is conducted before service testing in order to establish a reasonable assurance that the test item can be service tested, at locations that include the climatic test sites, with a minimum of risk to personnel. A successful safety evaluation permits an aircraft Safety Release by TECOM, as defined in TECR 385-6. Most data for the safety evaluation are obtained from the early portion of the suitability (engineering) test, but all appropriate data from the engineer design test are also used. A separate safety evaluation is also normally made a part of the initial production test to meet the requirements of AMCR 700-34.

The safety evaluation encompasses three phases: the prefiring phase, the ground-firing phase and the aerial-firing phase. In general the prefiring phase consists of: a study of the Safety Statement obtained from the developer (par. 6.1.2), an examination of the design of the test item to uncover possible safety problems, a review of prior testing including engineer design tests conducted by the developer of the item and similar items, and an examination of the item for adequacy of manufacture. Physical measurement (6.2.1 above) and static loading (par. 6.2.3.5) are part of this phase.

The ground-firing phase for the safety evaluation will include as a minimum the extreme temperature tests (+145° and -50°F, par. 6.2.3.1); operational vibration (par. 6.2.3.4); humidity tests (par. 6.2.3.2); ground-to-ground firing for safety, durability, and reliability (par. 6.2.4.1); and ground-to-ground firing for aircraft compatibility (par. 6.2.4.2).

With a safety-of-flight release (par. 6.1.2) and ground-firing data on hand, aerial-firing tests can be conducted (par. 6.2.4.4). When, in the (engineering) judgment of the test director, sufficient firing has been conducted to provide confidence of safety, a recommendation for a Safety Release, with supporting data, is forwarded to TECOM headquarters.

Most of the data acquired during the safety evaluation are also used to evaluate performance of the subsystems.

6.2.3 Environmental Tests

6.2.3.1 Performance at Temperature Extremes

Extreme-temperature tests are performed in accordance with AR 70-38.

a. The preferred high temperature test method consists of attaching the launcher and associated electrical fire control equipment to a suitable mount, or to a helicopter, and exposing it in a chamber to the temperature-solar radiation diurnal cycle specified for a hot-dry climate in AR 70-38. The rockets are exposed simultaneously. When peak launcher temperature is attained, the launcher is fully loaded and ripple fired through an opening in the chamber. The launcher is then reloaded and ripple fired again.

If it is necessary to use a chamber without capability for the above procedure, the items are conditioned to an approximate equivalent temperature and firing is conducted outside of the chamber. In this case the equivalent temperature (air temperature plus solar effects) may be assumed to be 145°F with soaking for 24 hours or until temperature equilibrium is attained.

A third type of facility is an open-bottomed, portable chamber that can be raised and removed, leaving the test item in place, once temperature conditioning has been completed.

b. For low temperature tests the launcher and fire control equipment, appropriately mounted, are conditioned at -35°F (intermediate cold) or -50°F (cold climate) unless another climate is specified. Cold soaking of the fire control equipment, launcher, and rockets is continued for 24 hours or until temperature equilibrium is attained. Firing (two ripples as with the hot test) is conducted from within the chamber if a suitable facility exists. Otherwise, the launcher will be moved outside - or if an open-bottomed portable chamber is used, the chamber will be raised and removed - and then the two ripples will be fired. To avoid temperature recovery, firing delays must be minimized once the subsystem is out of the chamber.

c. Any difficulties and malfunctions occurring during the hot or cold tests are recorded.

6.2.3.2 Sand and Dust, Humidity, Salt Spray, and Fungus Tests

The launcher is exposed in environmental chambers to sand and dust, humidity, salt spray, and fungus environments. Specifications for these and other environmental tests are found in MTP's 4-2-818, 4-2-819, 4-2-820, and MIL-STD-810B. Following each exposure to an environmental treatment the launcher is inspected for damage, and firing tests are performed as in 6.2.3.1 above (two full-load ripples of rockets).

NOTE: The electrical fire control equipment should be exposed to the humidity and fungus tests only.

Following the environmental chamber exposure to salt spray, the inspection for damage should include a search for stray voltages in the launcher caused by galvanic action. Alternately, checks for galvanic action may be made by spraying a salt water solution on and in the launcher and then, using sensitive instruments, checking voltage and current between the launcher firing contact and the launcher electrical ground. If measureable stray voltages are found, the corresponding electrical power must be determined to be far less than the minimum required to fire a rocket motor squib.

6.2.3.3 Rain and Freezing Rain

A rain test is performed in accordance with MTP 2-2-815. If a suitable test chamber is not available, it may be necessary to set up the launcher on a ground mount and test-fire during a natural rainfall, supplemented by artificial rain (as could be provided by a fire hose with fine spray nozzle supported over the test launcher). After the required exposure period, the launcher is ripple fired, reloaded, and ripple fired again. Any misfires or other malfunctions are noted and the causes determined.

A freezing rain test is conducted in accordance with MTP 2-2-815. Two test phases are required: first, exposure of unloaded launchers to freezing rain followed by attempts to load the launcher; second, exposure of a loaded launcher to freezing rain followed by attempts to fire. Ice deposits should not be permitted to exceed one-half inch in thickness during the above tests.

6.2.3.4 Laboratory Vibration

Laboratory vibration tests are conducted to determine whether rocket launchers and related components, including electrical fire control equipment, are dynamically compatible and structurally capable of withstanding the forces associated with aircraft flight vibration. These tests are conducted during the safety evaluation. The launcher, with inert ammunition components* installed, is mounted on an electrodynamic vibrator to simulate, as closely as possible, the method of attachment to the aircraft. The control accelerometer is mounted on the fixture "hard point" where the launcher is attached so as to properly describe the input vibration environment to the launcher. The fire control equipment is installed in an appropriate mounting bracket.

Unless the commodity command has furnished precise information regarding the dynamics of the launcher transmissibility characteristics over the broad frequency range of interest, these should be determined for the various load configurations.

Ideally, the loaded launcher is then vibrated to the periodic vibration spectrum and amplitudes associated with the particular helicopters on which it is flown, to determine its structural adequacy. Duration of the test should be commensurate with the particular component's design life and in terms of the required number of missions to be flown. In the absence of specific "worst case" flight data, the vibration schedule found in MIL-STD-810B may be used for guidance. The schedule should be tempered in terms of known characteristics of the aircraft which fly the items; for example, maximum longitudinal g forces experienced on rotary wing aircraft are usually about one-half of the maximum vertical g forces. Tests are conducted at both -50° and +145°F.

Results of laboratory vibration of the launchers, their sighting devices, or their related electronics equipment should be interpreted on an individual basis. Specific knowledge of an item's transmissibility

*Inert components are satisfactory for a launcher test. A rocket test would require certain live components to prove safety.

characteristics and the periodic spectrum of the aircraft are invaluable in making these assessments. A sinusoidal dwell test at the natural resonant frequency of some poorly damped item often will cause extreme damage. A test item that appears to have failed a standard vibration test may have been especially designed to have a lightly damped resonant frequency in a portion of the spectrum that is not excited by the operational vibration input from the applicable aircraft.

6.2.3.5 Static Loading

Static loading tests are conducted to simulate g loadings achieved during aircraft flight and landing. The launcher is mounted on a rigid fixture in a manner to simulate installation on the aircraft. To simulate the required g loads, static loads are applied to the launcher by means of static weights, hydraulic jacks, or turnbuckles. A typical setup is shown in Figure 2. If hydraulic jacks or turnbuckles are used, the applied forces are measured with load cells.

Deflections are measured with dial indicators. The use of strain gages at critical stress points may be desirable. Loading criteria are frequently specified in the applicable MN. Accelerations shown in Table II have been used as criteria for the testing of launchers and associated equipment used on rotary wing, utility aircraft.

Table II - Acceleration Criteria

Individually Applied Loads (g's)
4 forward 4 downward 2 upward 2 lateral (inboard and outboard)
Simultaneously Applied Loads (g's)
3.6 down, 1.82 forward, 0.62 inboard 3.6 down, 1.82 forward, 0.62 outboard 3.6 down, 1.82 rearward, 0.62 inboard 3.6 down, 1.82 rearward, 0.62 outboard

The following factors should be considered when conducting the static loading test:

a. The applied loads are based on the weight of a fully loaded rocket launcher. Inert rockets should be installed in the launcher.

b. When applying loads in the upward or downward directions, consideration must be given to one g loading caused by gravity. For example, if it is desired to simulate 4 g's downward on an item weighing 65 pounds, then 3 additional g's times 65 or 195 pounds of static loading must be applied. An upward loading or 2 g's would also require application of 195 pounds (65 pounds are required to overcome gravity, 130 pounds are required to simulate 2 g's).

c. The static loadings must be applied at the center of gravity of the test item, in such a manner that no undesirable effects (such as buckling of the launcher skin) are caused by point loading. Figure 2 illustrates the use of a saddle that distributes the applied static loads over a large surface area of the launcher skin and provides convenient "hard points" for attachment of loading devices. The additional weight of this saddle must also be considered when loads are applied upward or downward.

d. If a combination of assembled components is to be tested, the masses of two or more assemblies should be considered separately and static loads applied individually through the CG of these assemblies. Referring to Figure 2, the masses and CG's of the loaded launcher and of the universal external stores and bomb rack assembly are determined independently, and static loads are applied to the centers of the two masses. Use of this procedure prevents excessive force from being applied to the bomb rack shackle and also prevents excessive coupling moment from being introduced to the external stores clevis pin joints that mount the assembly to the aircraft. Launcher quadrant elevation settings are measured before, during, and after each application of static load. Failure of the test item to recover the original setting after removal of the test load, or excessive deflection under loading, should be noted and the cause determined.

e. Post-test inspection should include measurements of launcher tube straightness and alignment. Any components that fail should be subjected to a metallurgical examination. During and after the tests, an inspection should be made for evidence of high stress points, such as cracked seams or welds, or buckling of the launcher skin.

f. Static loading tests as described above may also be conducted to simulate forces developed upon the launcher during rocket firing. These forces are first measured by installing strain gages at critical locations on the fixture (on the launcher structure, on the launcher attaching lugs, etc.), mounting the launcher to a grounded helicoper, and firing rockets singly and in ripples. The launcher is then mounted on a test stand as shown in Figure 2, and the peak stress levels developed during rocket firing are redeveloped by application of static loads. Repeated overstressing of the launcher (to perhaps 130 percent of the previously measured peak stress value) would provide assurance that the launcher is capable of withstanding the forces developed during firing.

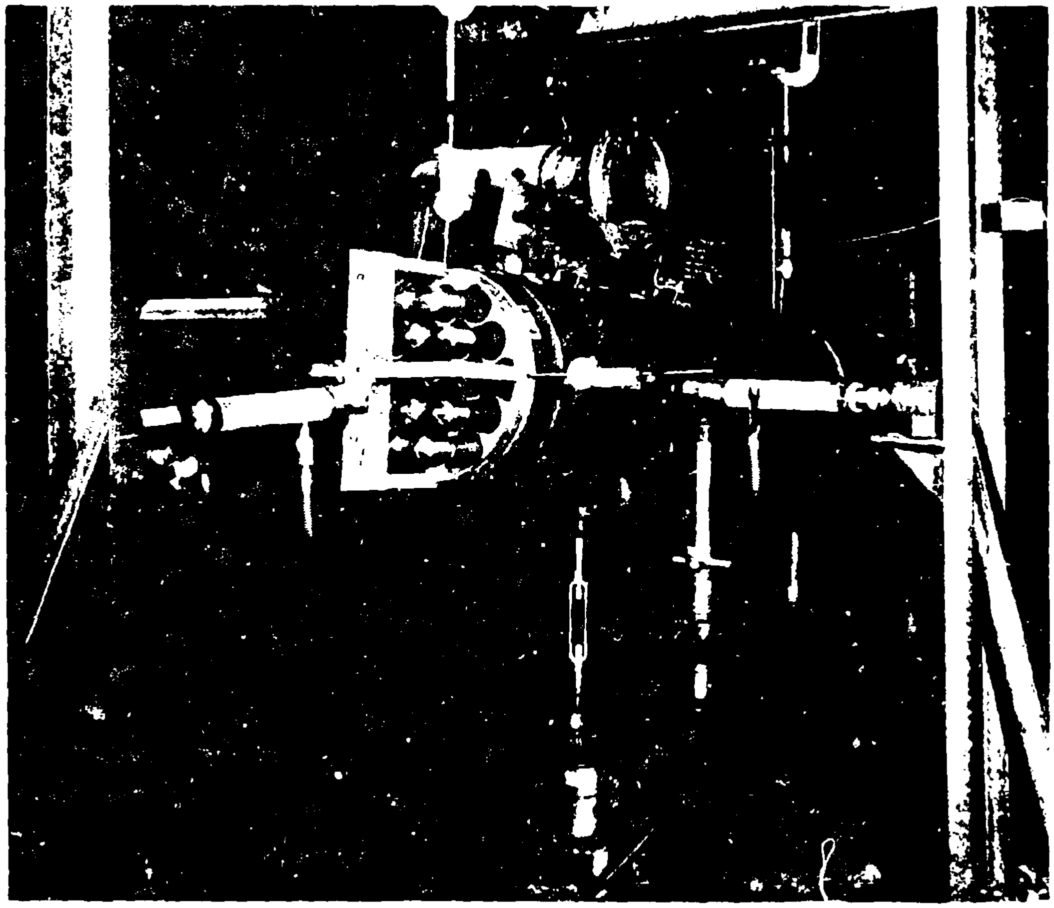

Figure [illegible]. Nineteen-Tube Rocket Launcher XM159 Mounted on Fixture in Preparation for Static Loading Test. A turnbuckle and a load cell are shown below the launcher. Hydraulic jacks and load cells are shown to the side and forward of the launcher. The launcher is loaded with inert rocket ammunition. Dial indicators are used to determine deflection under load.

6.2.4 Firing Tests

Ground-to-ground followed by air-to-ground firing tests are conducted to determine safety, performance, durability, accuracy and dispersion, and other characteristics as required for a thorough evaluation of the test launcher.

6.2.4.1 Ground-to-Ground Firing for Safety, Reliability, and Durability (Launcher Mounted on Test Stand)

Rocket firings from a launcher mounted on a test stand are conducted to determine the safety, reliability, and durability of the launcher. A typical test procedure is to fire 10 rounds from each launcher tube, followed by firings from three tubes until each has fired enough rockets to demonstrate the required launcher durability characteristics (or has failed). Firing rockets to 125 percent of the tube life requirements is adequate to demonstrate durability. Any stoppages or other malfunctions are noted. If cleaning or adjustment of the launcher is required to continue the firing test, this is also noted.

Following the test the launcher is cleaned and examined. Examination includes inspection for cracks, erosion, or other damage to launcher electrical contacts and other components that may be exposed to the rocket gas flow during firing; stargage and borescope examination of the launcher tubes; and measurement of rocket detent force.

6.2.4.2 Ground-to-Ground Firing (Compatibility of Rocket Launcher With Aircraft)

Firing tests are conducted with the launcher mounted to a grounded aircraft to demonstrate that:

a. Clearance between the rocket launcher and the aircraft and associated equipment is adequate to prevent a rocket from striking the aircraft during firing (including setting the rocket launchers at the maximum elevation, and considering the maximum droop of the rotor blade).

b. There will be no damage to the aircraft created by rocket backtlast or secondary missiles during firing.

NOTE: Particular attention must be paid to secondary missiles that could strike the tail rotor on rotary wing aircraft. Witness screens or collection boxes should be set up behind the launchers to determine the extent of any hazard created by the rocket firing.

c. Steady-state and intermittent electrical power requirements of the launcher(s) are satisfied, and that these are compatible with, and do not exceed the power available from, the aircraft power supply (TOP 1-2-602).

d. Launcher elevation limits are satisfactory. Used in conjunction with a standard bomb rack assembly or other mounting method, the launcher must be capable of elevation in accordance with the specified range capabilities of the weapon system without creating an installation safety hazard. Upper and lower elevation compatibility with safety requirements is determined.

6.2.4.3 Ground-to-Ground Firing for Ballistic Characteristics

Firing tests using a test stand or a grounded helicopter are conducted to determine the range, deflection, time of flight, tipoff angle, and velocity near launch of rockets fired from the test launcher. If the launcher is an integral component of a new aircraft weapon system, these tests are planned and conducted in conjunction with ground-fired ballistic tests of the complete weapon system. A typical testing procedure includes firing rounds at launcher quadrant elevations of 6, 15, 30 and 45 degrees. Surface and upper air meteorological data are obtained during the test as required for reduction of ballistic data to prepare a range table.

NOTE: It will be necessary to conduct the higher elevation firings from a test stand, due to the elevation limits of launchers mounted to the aircraft. Ground firing procedures as described in 6.2.4.1 through 6.2.4.3, above, and ground firing for environmental tests should be combined, when practical, to minimize ammunition requirements.

6.2.4.4 Firing From Airborne Aircraft

Rocket firings from airborne aircraft are conducted to determine the operability of the rocket weapon subsystem at various aircraft speeds and altitudes at which the launcher will be deployed and to measure the corresponding horizontal ranges to ground impact. Aerial firings will not be conducted until a safety-of-flight release for the aircraft type, rocket launcher, and ammunition to be used is provided by the U. S. Army Aviation Systems Command, and until sufficient ground testing and firing have been conducted to demonstrate that aerial firing may safely be conducted. The aerial firings are conducted with launcher and sighting system properly installed and boresighted in accordance with applicable installation procedures provided in operating and maintenance manuals. An aiming target is used on the firing range. For range estimation purposes, reference markers are located on the ground at various ranges from the aiming target along the designated line of fire. A typical range layout is shown in Figure 3. The quantity of rounds to be fired and the amount of data to be recorded will vary according to previous test history available on the system. The data indicated in a through e below normally suffice when the launcher under test is intended to become part of an existing weapon system.

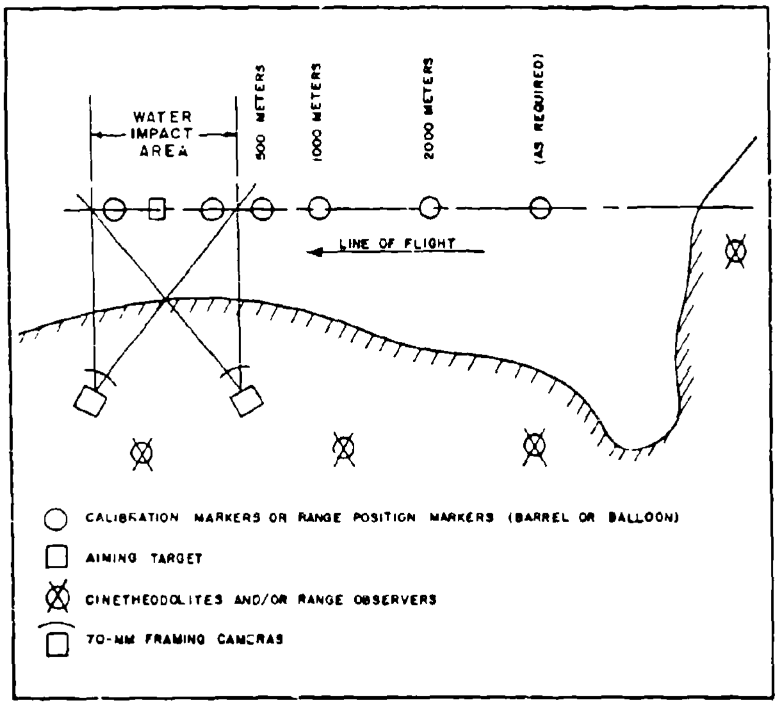

Figure 3. Typical Water-Impact Range Layout for Air-to-Ground Rocket Firing.

a. The airspeed and altitude at the moment of firing as indicated on the aircraft instrument panel.

b. The sett[illegible] of the pilot's (rocket) sight for each firing run, in degrees or mils [illegible] or below the aircraft waterline, or as specified.

c. Range, d[illegible]on, and time of flight (stopwatch) for rounds fired singly or in pairs [illegible]ined by observation and triangulation. Ranges and deflections are orig[illegible] at the appropriate range reference marker except when aircraft posi[illegible]oordinates are determined with cinetheodolites (f below). In this case, [illegible]s and deflections are originated at the aircraft position at the time o[illegible] iring. Deflection is given relative to the line of fire from the aircraft to the aiming target.

d. Range, deflection, and time of flight for multiple-round firings (ripples) determined by photography and visual observation and triangulation.

1) If the firing can be conducted on a water impact range, the aerial photography method is used to determine the impact patterns. For this method barrels, polystyrene, or large balloons are located in the impact area for photographic calibration purposes, and an aerial camera is mounted on a helicopter that hovers directly over the impact area during the ripple firings. This helicopter must be located above the maximum ordinate of the rockets to be fired. Figure 4 illustrates a typical serial photograph taken during rocket firing test to analyze the impact pattern.

Figure 4. Seven Rocket Impacts on Water Viewed From an Aerial Camera Mounted on a Helicopter Hovering 4000 Feet Over the Impact Area. Barrels are anchored in the impact area for aiming and calibration purposes. The direction of fire is indicated by the arrow.

2) An alternate or backup photographic system for obtaining ripple impact data consists of positioning two or more 70-mm framing cameras at ground stations so that their fields of view intersect at the impact area (Figs. 3 and 5). This setup can be used on land or water ranges. These cameras must be linked with a common time coding system. Also, ranges, deflections, and times of flight for the longest and shortest round of each ripple should be obtained by range observation (these rounds are frequently missed by the photographic instrumentation). Reduction of the data obtained with the 70-mm cameras is more time-consuming than with the aerial camera data, as the round impact locations must be determined by the plotting of intersections.

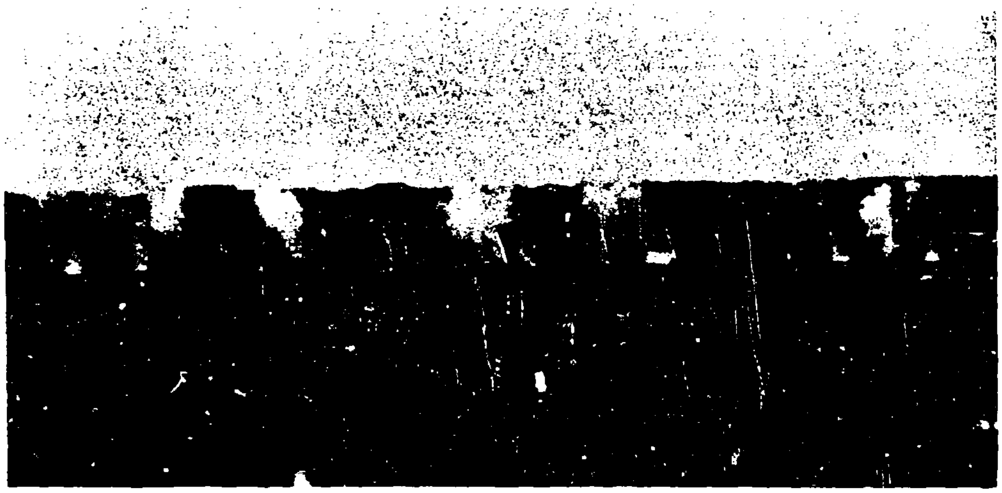

Figure 5. Ten Rocket Impacts Upon Water Photographed With 70-mm Camera Located as Shown in Figure 3.

e. Meteorological data, including surface winds at the test site and meteorological data aloft, when operating above 2000-foot altitude.

NOTE: The measurements described in f through i below are obtained only when data of "firing table" quality are desired.

f. Aircraft position and velocity at the moment of each rocket firing, determined with cinetheodolites (tracking cameras). Use of cinetheodolites is discusses in MTP 5-1-031. Positive indication of the time of each rocket firing can be obtained by radio transmission from the firing aircraft.

g. Pitch, yaw, and roll of the aircraft at the time of rocket firing determined. Yaw is measured relative to the direction of motion of the aircraft.

h. Rotor downwash at the weapon at the moment of firing. Figure 6 shows a Pitot tube and wind vane installed on a UH-1 helicopter for the purpose. Recording equipment is located within the aircraft.

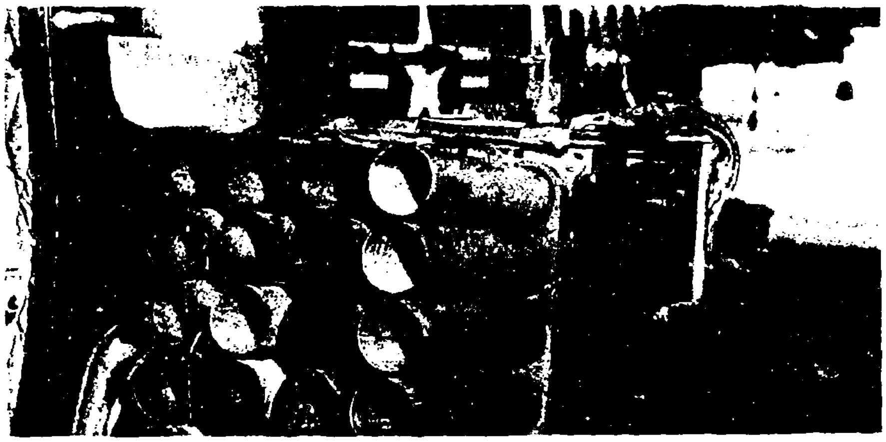

Figure 6. Pitot Tube and Selsyn Wind Direction Indicator (Arrows) Used to Determine Rotor Downwash.

i. The aiming point of the pilot's (rocket firing) sight at the moment of firing. The method for determining this point depends upon the type of sight and installation. One method, which may be used with infinity-reflex type sights, requires the use of photographic equipment. The sight is set at the required degrees or mils to provide impacts in the target area during flight operations. It is necessary to arrange the flight schedule so that tests requiring a particular sight setting are conducted during a single series of operations. A 16-mm camera is mounted on the aircraft (Fig. 7). The camera and sight are collimated by aiming the sight at a distant object (preferably at the maximum weapon range) with the aircraft on the ground. The camera is aimed at the distant object, secured in position, and operated. Suitable calibration targets are located in the camera field of view for later use in determining aiming error angles. The camera is operated during aircraft firing runs, photographing the aiming target on the firing range. Since collimation of the camera must be repeated whenever the sight setting is changed, settings cannot be changed during aircraft flight. (Exception: minor changes may be made if a calibration curve of sight setting vs angular changes in the line of sight is available for the particular sight in use.) It is highly important that the position of the 16-mm framing camera not be disturbed during the test operation. Collimation of the sight and camera are repeated after each series of test flights, to assure that the camera has not moved due to the aircraft vibration or from accidental contact by test or aircraft maintenance personnel.

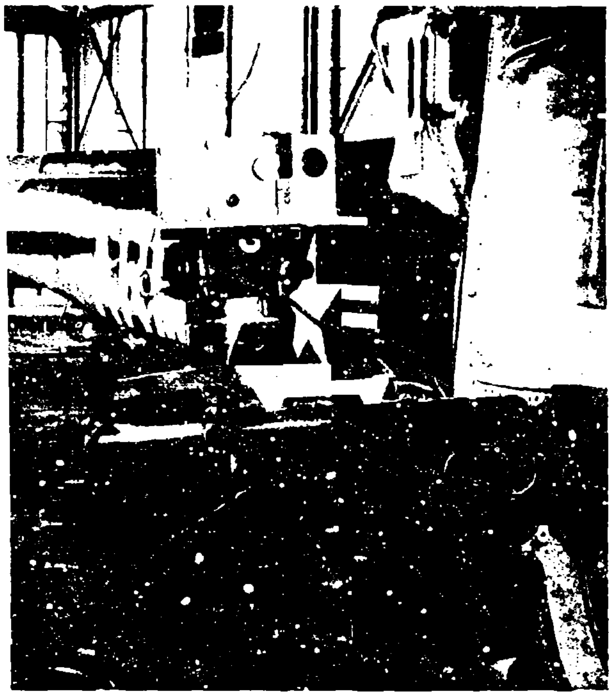

Figure 7. A 16-mm Camera Mounted to an XM-3 Armament Subsystem (2.75-Inch Rocket) for use in Determining Pilot Aiming Error. The camera is collimated with the pilot sight before use.

6.3 TEST DATA

Test data requirements are summarized under 6.1 and 6.2, above.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Physical Characteristics

The data taken before the test (par. 6.2.1) are compared with the measurements obtained after the environmental and rocket firing tests.

6.4.2 Environmental Tests

Launchers subjected to environmental treatments are compared statistically with control launchers (i.e., launchers not subjected to environmental treatment) to determine whether the environments have had a significant effect on safety, performance, and durability requirements.

6.4.3 Firing Tests

a. Average range and deflection (probable error in range and deflection) of rockets fired from the launcher mounted on the test stand are computed.

b. A preliminary table is prepared showing pilot's sight settings required for use with the airborne rocket-launcher system.

c. Average range and deflection)probable error in range and deflection) of rockets fired from the airborne launcher are plotted at the various aircraft speeds and altitudes and at various ranges from aircraft to target.

d. The pilot's aiming error is determined, when required, using the 16-mm camera records. The angular difference (transverse and vertical) at the moment of firing between the aiming target and the distant object used for sight-camera collimation is measured.

e. The firing test data are analyzed to determine:

1) Whether the launcher meets the requirements stated in the MN or other specification for safety, performance, and durability (number of firings per tube).
2) The maintenance requirements for the launcher.

GLOSSARY

1. Aircraft waterline: The aircraft orientation in the traverse and longitudinal planes specified by the manufacturer as being "level." This orientation may be obtained on the ground by marker plates located on the aircraft and a surveyor's plumb bob, and with the aircraft positioned with hydraulic jacks. Armaments and sighting equipment elevations are set relative to this waterline.

2. Armament subsystem (system): Armament (rockets, grenades, missiles, machine guns, etc.) which may be installed to aircraft, available as an installation kit containing all necessary hardware, sighting equipment, installation instructions, and operating manuals. Aircraft for which armament subsystems are available are prewired for use of one or more types of installation kits. Sometimes more than one type of armament may be mounted to aircraft simultaneously (example: 2.75-inch rockets and 40-mm grenades). In this event, the compatibility of the armament subsystems must be established by testing before this combination is used.

3. Bomb rack or bomb shackle: A quick-release latching mechanism developed for use with aircraft bombs and widely used in mounting rocket launchers and other armaments to armament subsystems or directly to the aircraft.

4. Collimate: To render optical axes or lines of sight parallel.

5. Damping: The dissipation of energy with time or distance.

6. Detent force: The force which the rocket motor thrust must overcome in order to start forward motion of the rocket from the launcher tube. This restraining force is created by a spring-loaded detent that engages the rocket when it is positioned in the tube. The detent force restrains the rocket in the launcher tube during aircraft flight prior to firing, and helps in delaying free flight of the rocket until rocket motor thrust has increased sufficiently to impart smooth, axially directed force to the rocket.

7. Dispersion: A measure of deviation about the center of impact of a group of rounds. Dispersion may be expressed as the standard deviation of range and deflection variations from the center of impact or as the probable (average) error of the above round-to-round variations.

8. Infinity-reflex sight: A unity power sighting system with the reticle pattern generated and focused to appear at infinity range on a flat combining glass. If the application permits, considerable freedom of operator head motion relative to sighting through the combining glass may be permitted without loss in the reticle pattern or target presentation. The sight is easily adaptable to ballistic and weapon lead angle compensation.

9. Jettison: Release of aircraft stores which have been expended, or, in an emergency, release of nonexpended or reusable stores as required to lighten the aircraft and/or improve the autorotation or glide characteristics.

10. Launcher electrical connector: Appendage for connections of the launcher electrical system to the aircraft system to complete the firing circuits, and other electrical circuits as required.

11. Launcher electrical contacts (fingers): Components for completion of the electrical connections from the launcher to each rocket motor. The launcher and rocket motor body act as the electrical ground.

12. Maximum ordinate: The greatest elevation reached by the rocket during its flight.

13. Safety-of-flight release: A statement indicating that a rocket launcher, rocket, or other store may safely be flown when properly mounted on the appropriate aircraft. Any restrictions on aircraft gross weight, center of gravity location, airspeed, etc., will be stated. The safety-of-flight release does not provide information concerning safety of firing rockets or other ammunition from the aircraft. AVSCOM has the responsibility for providing a safety-of-flight release on items intended for Army use.

14. Transmissibility: The nondimensional ratio of the response amplitude of an item in steady-state forced vibration to the excitation (input) amplitude.